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FIRST RESULTS OF THE ALOS PALSAR VERIFICATION PROCESSOR

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ABSTRACT

Among the several applications that will take advantage of the newly available data from the ALOS PALSAR instrument, considerable interest is in the peculiar features that derive from the penetration and polarimetric capabilities of the system.

These capabilities, new for a single spaceborne sensor, need specific software tools for the processing of the different acquisition modes. This paper presents a verification processor, developed under ESA contract, for the generation of polarimetric, interferometric and polarimetric-interferometric geocoded products derived from ALOS PALSAR data.

The processor, developed with a modular approach, contains the following main elements:

- Phase-preserving fine resolution processor;
- Phase-preserving ScanSAR processor;
- Interference removal tools;
- Polarimetric calibration tools;
- Polarimetric analysis tools;
- Fine resolution interferometric processor;
- ScanSAR interferometric processor;
- Polarimetric-interferometric processor;
- Geocoding;
- Atmospheric modelling tools.

The processor architecture is presented; highlights are given on specific modules and algorithms. Early results are shown, in particular of the processing of polarimetric and polarimetric-interferometric data over different test sites.

1 INTRODUCTION

The successful launch of ALOS satellite [1], thanks to the peculiar L-band frequency and full-polarimetric acquisition capabilities of its PALSAR instrument, opens new perspectives in the field of interferometric and polarimetric applications. The PALSAR characteristics and acquisition modes are summarized in Table 1.

Table 1. Polarimetric calibration over Corner Reflectors

Mode	Fine Resolution	ScanSAR	Polarimetric (Experimental mode 1)
Center Frequency	1270 MHz		
Bandwidth	28 / 14 MHz		
Polarization	HH or VV / HH+VV or VV+VH	HH or VV	HH+HV+VH+VV
Resolution	10 m (2 look) / 20 m (4 look)	100 m (multi look)	30 m
Swath Width	70 km	250 ~ 350 km	30 km
Incidence Angle	8 ~ 60 degrees	18 ~ 43 degrees	8 ~30 degrees
NE sigma zero	< -23 dB < -25 dB	< -25 dB	< -29 dB
S / A	> 16 dB / > 21 dB	> 21 dB	> 19 dB
Bit length	3 bits / 5 bits	5 bits	3 bits / 5 bits
Antenna Size	Azimuth: 8.9 m, Elevation: 2.9m		

A processor has being developed under ESA contract for the verification of the potentialities of PALSAR data for different interferometric, polarimetric and polarimetric-interferometric applications.

2 SYSTEM OVERVIEW

An overview of the verification processor is shown in 0. A number of modules and packages are available to allow an end-to-end approach, starting from PALSAR raw data up to geocoded products obtained through different techniques.

Phase-preserving fine resolution and ScanSAR processors: an Ω -k approach is used to guarantee the preservation of all phase information, necessary for the sub-sequent processing steps. The ScanSAR phase-preserving processor is particularly innovative, extending all coherent applications to the use of wide-area data [2][3]. As opposed to the products provided by Jaxa, the verification processor delivers Zero-Doppler annotated products.

Interference removal tools are included within the processors due to the high occurrence of interferences in L-Band . A number of approaches are implemented, based on a statistic of the interference types that have been detected in the PALSAR raw data up to now.

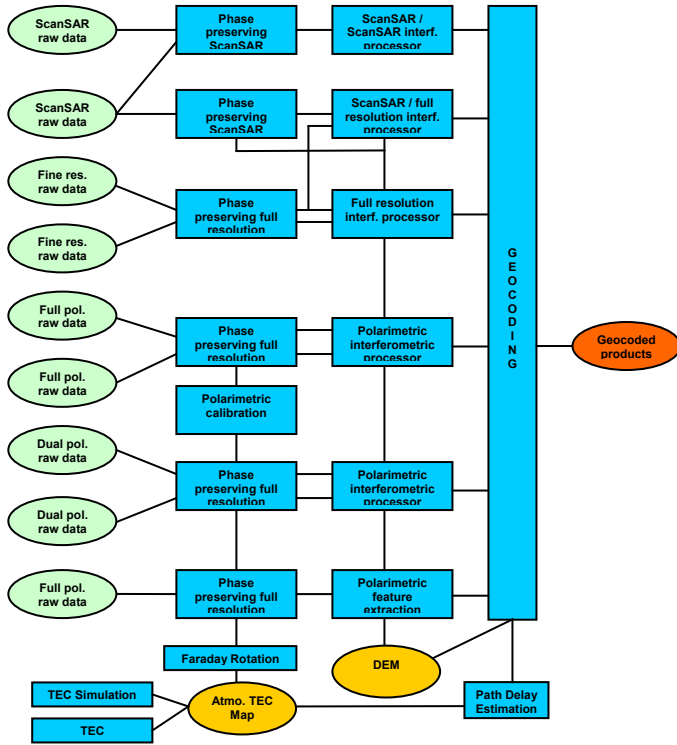


Fig. 1. System overview.

Polarimetric calibration tools allow the correction of system-induced effects and the reconstruction of the real scattering matrix of the imaged areas from the measured one.

Polarimetric analysis tools are provided like polarimetric signature analysis, polarisation synthesis and decomposition, coherence estimation as well as polarimetric classification.

Fine resolution and ScanSAR interferometric processors allow the computation of coherence maps and Digital Elevation models, both from fine resolution or ScanSAR data as well as from combinations of the two types of products.

Polarimetric interferometry modules are provided to perform coherence optimisation based on an adaptive approach as well as perform parameter inversion to obtain information concerning tree heights.

Geocoding; a rigorous approach, based on a DEM and the solution of the Range-Doppler equations of the system is adopted both for the geocoding of the final products and for the generation of the synthetic fringes used during the interferometric processing.

Atmospheric modelling tools: they provide path delay estimates for use in the geocoding step, starting from

total electron content (TEC) map estimates describing spatial variations in TEC values across the Earth. These estimates are obtained either from GNSS measurements or from simulations [5].

3 PRELIMINARY RESULTS

The following figures present a number of early results obtained with the different modules of the verification processor.

Fig. 2 shows the azimuth time – range spectrum distribution of a segment of ALOS raw data. Here it is possible to notice how different types of interferences appear: band & time-limited, single instant tones as well as continuous tones at specific frequencies.

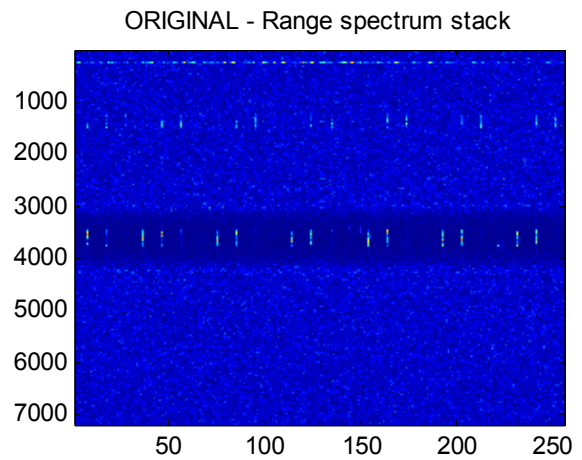


Fig. 2. Azimuth time – range spectrum distribution of a segment of ALOS raw data.

Another type of artefacts detected is shown in Fig. 3. It has been detected that, in some lines after the occurrence of some type of interferences are showing an overall lower value of the spectrum when compared with the expected one as computed from the information on the transmitted chirp power and on the average of the power of the previous lines.

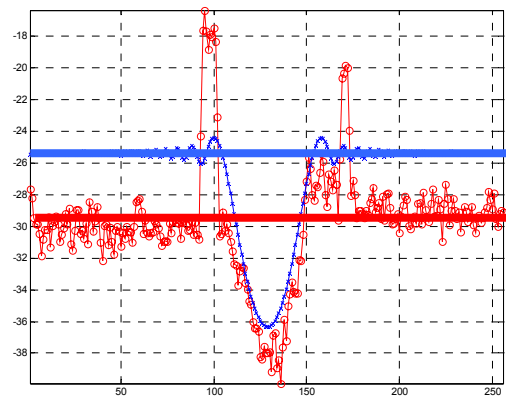


Fig. 3. Power loss effect. Real data range spectrum in red; expected spectrum in blue.

Fig. 4 shows the result of applying some of the implemented approaches to interferences removal, evident when comparing the upper image (not corrected) with the lower one.

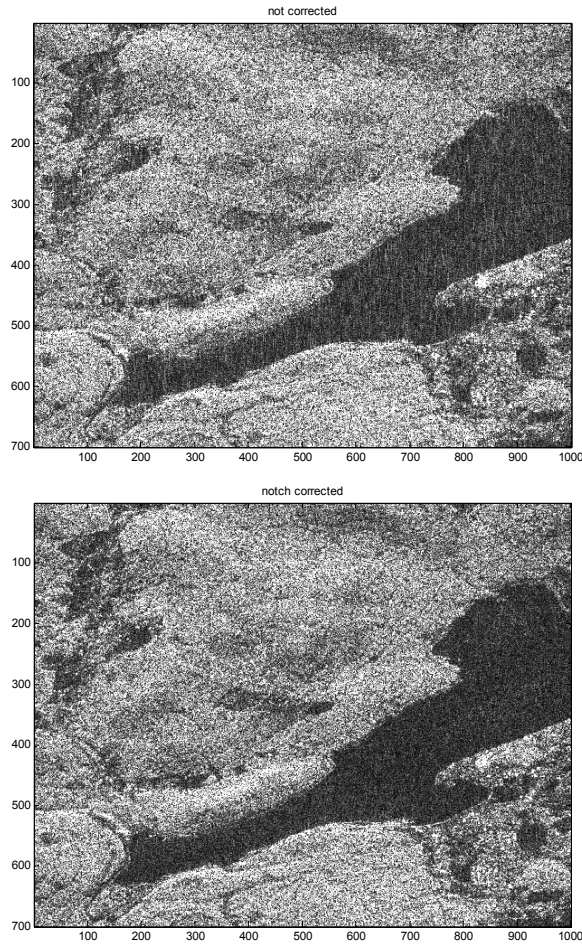


Fig. 4. Interferences removal. Data affected by interferences (above) vs. interference-removed data (below)

Table 2. is showing an evaluation of the polarimetric calibration of full-polarimetric data, as provided by Jaxa and evaluated on the Corner Reflectors installed around the DLR area (Oberpfaffenhofen, Germany). The results are very promising. The development now concentrates in the integration of the TEC maps obtained from the atmospheric modelling tools into an alternative calibration chain, to help the correction of the Faraday rotation effects, and in a DEM-dependant correction of the Antenna Gain Pattern values to be performed before the polarimetric calibration step.

Table 2. Results of polarimetric calibration over Corner Reflectors.

CR	Shift HH-VV	Power Imbalance HH – VV	Power Imbalance HH – VV (dB)	Phase Imbalance HH – VV (deg)
Etterschlag	DR=0 DA=1/32	0.98	-0.4	0.0007
Gilching	DR=0 DA=-1/32	0.99	-0.1	0.0006
Maising	DR=0 DA=7/32	1.01	0.2	0.006
Tiefenbrunnenn	DR=0 DA=0	0.97	-0.6	0.0003
Unterbrunnenn	DR=1/32 DA=0	0.95	-1.0	-0.0003

The accuracy in the localisation of the PALSAR data that can be obtained based on the provided ancillary information (state vectors) only, without GCPs, is being checked with the support of Corner Reflectors, shown in Fig. 5, installed for this project.



Fig. 5. Corner Reflector installed in the Zurich region (Switzerland).

Fig. 6 compares the expected location of the response of a such corner reflector within three different ascending or descending ALOS frames with that identified from the Level 1.1 images, as provided by Jaxa. Based on the analysis of a limited number of datasets, it may be expected an accuracy of around one pixel in the absolute localisation of the Jaxa products based on ancillary information only.

After correcting some systematic delays, comparable results are reached with the verification processor.

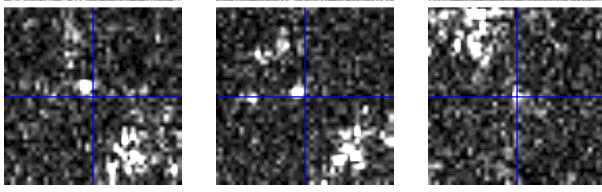


Fig. 6. Comparison between the predicted location (blue line) and the real image location of a Corner Reflector in three different ALOS scenes. The images are oversampled by a factor of 3.

The accuracy of the orbital information and geometric accuracy of PALSAR data has been checked also against the capability of providing reliable information for the estimation of relative shifts in case of interferometric combination. The results of the shifts as obtained from orbits with the ones obtained by maximising the interferometric coherence are shown in Table 3. It can be seen that the accuracy of the shift parameters obtained from the orbital information, when considering a correct reference height for the area, is in the order of a fraction of a pixel, and particularly good in range direction. These results are of particular interest for the case of ScanSAR interferometry.

Table 2. Comparison between coregistration parameters obtained from the orbital information with those obtained from the SLC data through coherence maximisation.

	Range shift polynomial	Azimuth shift polynomial
Orbital shifts with 600m reference height	364.29 + Rg * 0.0033 - Az * 0.00011	682.94 + Rg * 0.00055 + Az * 0.00356
Coherence maximization	364.26 + Rg * 0.0033 - Az * 0.000097	682.36 + Rg * 0.00054 + Az * 0.00357

One example of a TEC map obtained from GNSS measurements close to the acquisition time of one PALSAR scene is shown in Fig. 7. Depending on the acquisition solar time and solar activity, the availability of such information may allow, in L-Band, to obtain information suitable to correct the absolute location of the products of some tens of metres.

One example of the first results obtained with the Polarimetric Analysis tools on PALSAR data is shown in Fig. 8. The accuracy of such classification map, obtained with an adaptive implementation of [4], is under evaluation, but is very promising in the discrimination of different land features like urban, water, forested and open areas.

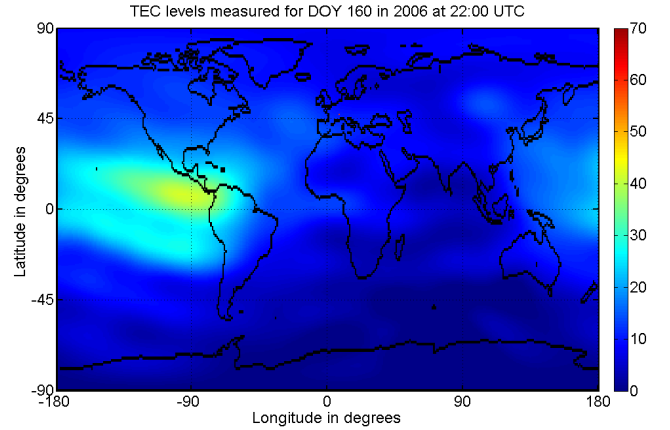


Fig. 7. TEC map obtained from GNSS measurements close to the acquisition time of one PALSAR scene.

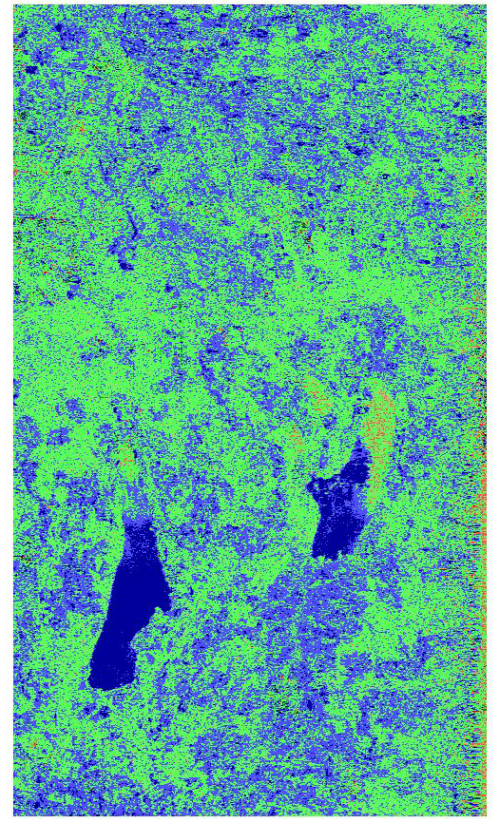


Fig. 8. Unsupervised α -Entropy classification of PALSAR data.

An example of results obtained with the interferometric processor is shown in Fig. 9 and Fig. 10 for a test site over Switzerland.

A comparison between flattening of PALSAR HH interferometric data based on a Digital Terrain Model (on the left, data copyright of Swisstopo) and on a Digital Surface Model (SRTM C-Band data) is shown in Fig. 9. A preliminary interpretation of these images is the following:

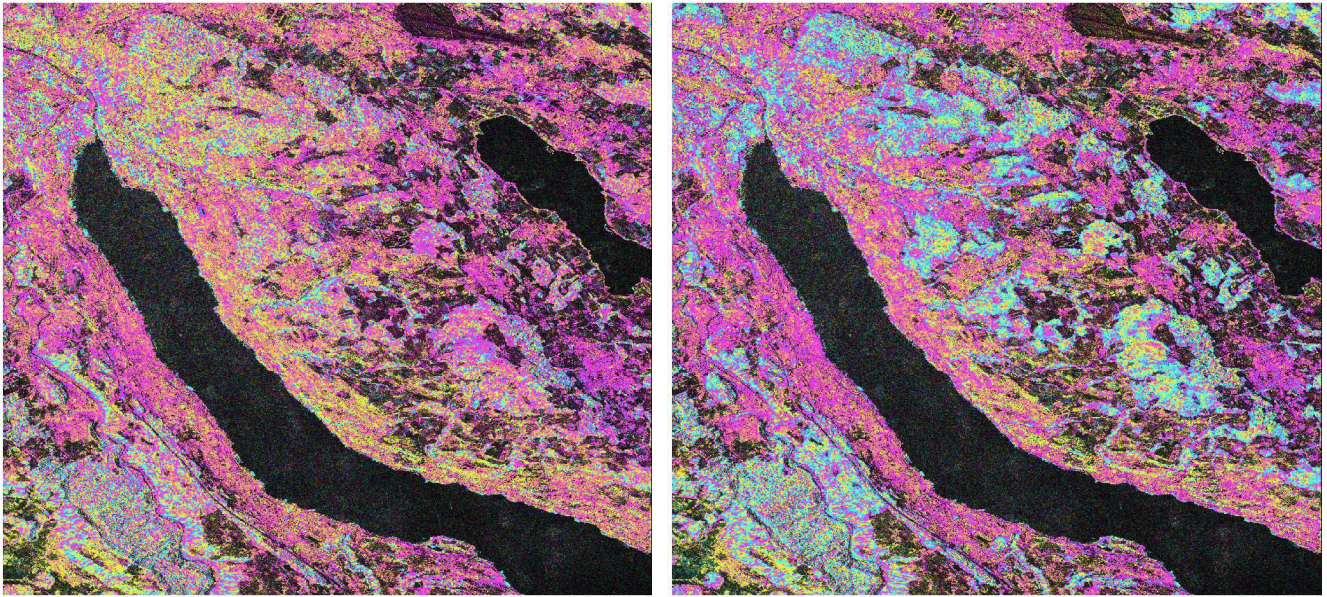


Fig. 9 Comparison between flattening of PALSAR HH interferometric data based on a Digital Terrain Model (on the left, data copyright of Swisstopo) and on a Digital Surface Model (SRTM C-Band data),

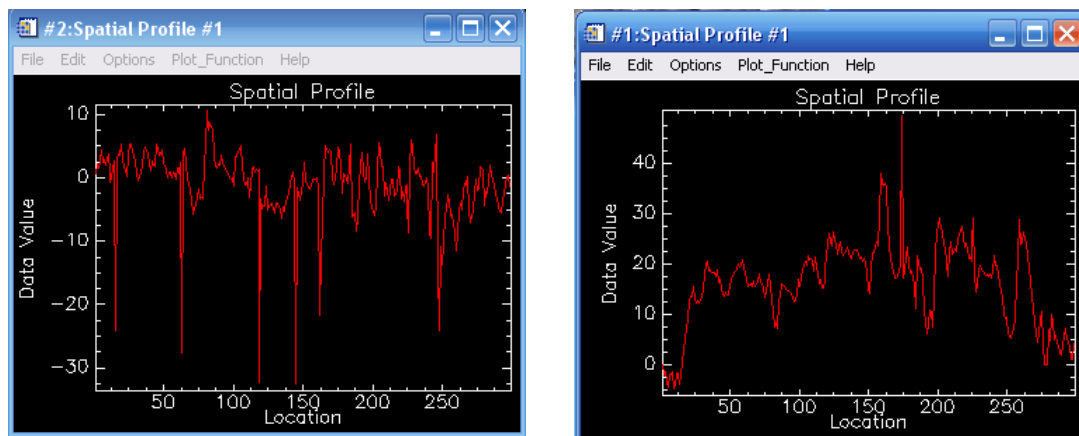


Fig. 10 Comparison of the difference of a PALSAR HH interferometric DEM with a Digital Terrain Model (on the left, data copyright of Swisstopo) and with a Digital Surface Model (SRTM C-Band data),

- HH acquisitions have been processed here, much sensitive to the double-bounce scattering mechanism of the tree trunks.
- This mechanism has a phase centre that corresponds to the centre of the trunk-terrain angle (tree base).
- The contribution of the leaves reflection (maybe already low because of L-band penetration) is quite incoherent with the time, hence filtered away during the interferogram filtering.
- The interferogram then mainly would show the phase of the terrain (close to that obtained from a Digital Terrain Model).
- On the other hand, when subtracting the SRTM phase during the flattening, a almost 0 phase in the non-forest areas (PALSAR \approx SRTM), while a kind of “hole” in the phase is showing up in the forested areas, that corresponds to (the negative of) the tree heights.

The difference of the DEM obtained from these data with a DTM (on the left) or respectively a DSM (on the right) is showed in Fig. 10 for a similar transect through a forested area. Here, beside some 2π phase unwrapping errors (2π height ambiguity around 28m for this pair), it can be seen how the HH DEM seems to correlate very well with the terrain height, and how the tree heights of the area could be extracted by differencing the PALSAR

HH DEM with the SRTM C-Band DEM. A more quantitative assessment of these results is ongoing.

4 CONCLUSIONS

The first results obtained from ALOS data using the described verification processor are very promising. In particular, they show that very accurate results in terms of processing, interference removal and absolute geolocation of the data may be obtained thanks to the system performances and to a careful processing.

The potentiality of PALSAR data for different land applications seem to be confirmed after a preliminary analysis of the data, and forestry applications, in particular, will particularly benefit from the availability of these data.

5 REFERENCES

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